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3 THE PROBLEM OF MAN'S GRAVITOINERTIAL FORCE ENVIRONMENT IN  
SPACE FLIGHT 4

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A distinguished group of specialists met in Pensacola, Florida, January 24-26 as participants in the third vestibular symposium. They came prepared to discuss a few of the many possible topics which fall under NASA mission-oriented research in the vestibular and related areas, and basic vestibular research not undertaken with anything in mind other than to increase our understanding of these poorly understood sensory organs. Dr. Jones, in his opening remarks, outlined a "systems engineering approach" with regard to the vestibular problems which may be encountered in manned space flight, which is at once useful to investigators charged with NASA mission-oriented research and not restrictive with regard to how this might best be accomplished:

"In a systems engineering approach, there are a number of discrete categories of effort. Let us consider the extent to which research activities in vestibular physiology fall within these categories. It may be that certain useful implications then can be drawn.

"A major category in a systems engineering analysis deals with the Definition of System Components. These studies are those which attempt to define, at an appropriate microscopic level, the precise morphology of the vestibular system.

"A second important category is that concerned with Delineation of Sub-system Function. While it is rather obvious by this time that the primary role of the vestibular system is to provide information to man concerning the orientation of his body in space, it seems there is still a great deal to be learned concerning the specific nature of vestibular components.

"In the third category, I would place those studies which describe the Scaling of System Operations. By this I refer to those studies which measure, with as great precision as possible, the response of a physiological system to a wide range of stimuli along a particular physical dimension. The response, either of the complete system or of individual nerve fibers, to a specific type of acceleration force is the basic issue of concern with studies in this category. However, I also would include studies which point out the manner in which a given sensory input can produce a perception which is in conflict with reality.

"The fourth category from systems engineering includes attempts to develop an Analytic Model of System Functions.

"The final category includes studies of the Effect of Atypical External Forces on System Function. Studies of habituation and adaptation to extended periods of rotation might be placed in this category. Also included are studies of the effects of

weightlessness. Finally, I would add those which examine the effects of change in the internal environment, that is, drug-induced biochemical changes, on the operation of the vestibular system.

"The exercise in systems engineering description which we have just gone through undoubtedly contributes little to the members of this audience by way of an increased understanding of the vestibular system. It does, however, offer me an avenue for describing the manner in which NASA views the potential contribution of these symposia.

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"In studying problems of disorientation under space conditions, which certainly constitute unusual environmental forces, there are two approaches which NASA might take. The first would be based entirely on inductive procedures and would involve collecting pieces of information from a large number of sources which show how the human reacts to some feature, actual or potential, of the space environment. For example, by simply taking the data from orbital flights to date, from rotating room studies, from sensory deprivation studies, and from centrifuge runs we can make a rather well-educated guess as to the likelihood of disorientation during a long-range mission. An inductive approach of this type certainly represents a very direct method of seeking an answer to a specific question.

"An alternative approach would be based more on deductive procedures and would involve developing a rather complete descriptive model dealing with the operation of the vestibular system. In terms of our classification scheme, this means focusing on category four, the Development of Analytic Models. However, as all model builders appreciate, the success of a model is very much dependent on the adequacy of the available information concerning specific characteristics of the system under study. We must know a great deal about the microstructure of the system. We must have insights into the function of specific system components. We must know the physiological response of system elements as the magnitude of a specific stimulus force is varied. In other words, again referring to our classification scheme, a worthwhile analytic model cannot be constructed unless research efforts within the first three categories are continuously providing information for inclusion within the model."

The opening presentation was made by Dr. Maxim Faget who reviewed the changing concepts in design of rotating orbiting spacecraft and the reasons why the so-called "I" design is currently favored. He discussed in some detail the problems posed to ensure "habitability" and drew interesting comparisons between volume of living space in proposed orbiting satellites and confined living quarters under arctic conditions. Although a decision has not been reached regarding the need or desirability of rotating a spacecraft

to provide artificial gravity, this approach is not being neglected. His paper was followed by four other reports dealing mainly with the side effects of exposure in rotating environments.

There was a brief session devoted to "circulation of the endolymph," and Dr. Dohlman, in his review of the subject, pointed out that we have little knowledge of how this "life support system" for the sensory epithelia functions. Despite the excellent work of Professor Dohlman and others, there exists here a serious gap in our knowledge.

Another session was devoted to the blood supply of the labyrinthine organs, and the opening paper was presented by Dr. J. E. Hawkins. The anatomical features of the labyrinth, of importance to a proper understanding of the vestibular cochlear aqueducts (concerned with the circulation of the endolymph) and the blood supply to the inner ear were presented in two excellent, beautifully illustrated reports by Dr. Barry Anson.

A series of four outstanding reports on the efferent vestibular fibers brought the listeners up to date with regard to the anatomical aspect of Rasmussen's bundle. The function of these fibers has not been elucidated.

The last two and by far the longest sessions were devoted to tests of otolith and of semicircular canal function.

"Labyrinthine Control of the Postural Muscles" was the title of Dr. T. D. M. Roberts' presentation in an interesting evening meeting. This provided the basis for Dr. Roberts' concept of a "behavioral vertical" with servo adjustment to bring the body into line.

These few remarks only touch on the subject matter which along with a complete transcription of the discussion will soon appear as the Proceedings of the Third Symposium.

#### Completed Reports

- 128.\* Miller, E. F., II, Fregly, A. R., and Graybiel, A., Comparison of visual judgments by subjects with known otolithic defects and normal persons tilted with respect to gravity.

12. Hixson, W. C., Niven, J. I., and Lowery, C. A., A head restraint device for vestibular studies.
130. Graybiel, A., Deane, F. R., Thompson, A. B., Colehour, J. K., and Fregly, A. R., Transfer of habituation on changes in body position between upright and horizontal in a rotating environment.
131. Miller, E. F., II, Drug effects on ocular counterrolling.
132. Clark, B., and Graybiel, A., Egocentric localization of the visual horizontal in normals and partially blind subjects during exposure to centripetal force.
133. Wood, C. D., and Graybiel, A., Antimotion sickness drug evaluation No. V - (Slow Rotation Room).
134. Fregly, A. R., and Graybiel, A., Identification of auricular defects by ataxia and threshold caloric testing.

\*Serial numbers.

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